

Toddlers' categorization of typical and scrambled dolls and cars

Michelle Heron^{a,*}, Virginia Slaughter^b

^a Department of Psychology, University of Sheffield, Western Bank, Sheffield S10 2TN, United Kingdom

^b Early Cognitive Development Unit, School of Psychology, University of Queensland, Brisbane 4072, Australia

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Abstract

Previous research has demonstrated discrimination of scrambled from typical human body shapes at 15–18 months of age [Slaughter, V., & Heron, M. (2004). Origins and early development of human body knowledge. *Monographs of the Society for Research in Child Development*, 69]. In the current study 18-, 24- and 30-month-old infants were presented with four typical and four scrambled dolls in a sequential touching procedure, to assess the development of explicit categorization of human body shapes. Infants were also presented with typical and scrambled cars, allowing comparison of infants' categorization of scrambled and typical exemplars in a different domain. Spontaneous comments regarding category membership were recorded. Girls categorized dolls and cars as typical or scrambled at 30 months, whereas boys only categorized the cars. Earliest categorization was for typical and scrambled cars, at 24 months, but only for boys. Language-based knowledge, coded from infants' comments, followed the same pattern. This suggests that human body knowledge does not have privileged status in infancy. Gender differences in performance are discussed.

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When investigating conceptual development in infants and toddlers, researchers have employed a variety of techniques. These include visual tasks such as preferential looking, habituation and violation-of-expectation, structured behavioral tasks such as manual search, directed imitation and object exploration, and unstructured behavioral tasks including sequential touching, as well as tasks requiring a verbal response. Over the last 30 years, research on conceptual development in the first 3 years has shown that the measured age of emergence for a particular concept is partially dependent on the procedure used to measure it (Keen, 2003; Mareschal & Quinn, 2001; Munakata, 2001). In general, tasks that require only visual responding, if they are taken to reflect conceptual knowledge (see Mandler, 1997, 2000 for discussion), reveal earlier conceptual knowledge than structured behavioral tasks (Keen, 2003; Younger & Furrer, 2003). Expressions of conceptual knowledge in spontaneous behavioral tasks are observed later (Oakes, Plumert, Lansink, & Merryman, 1996). Therefore a thorough description of conceptual development requires testing with multiple procedures (Woolley, 2006). This approach allows researchers to replicate basic phenomena and explore how conceptual development in a given domain interacts with behavioral response systems.

A large body of research has documented the early emergence of knowledge regarding the configuration of the human face (Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991). Recently, infants' ability to recognize the typical configuration of the human body shape has also been investigated. Slaughter and Heron (2004) investigated this in a series of visual habituation tasks, in which 12–18-month-old infants were presented with line

* Corresponding author. Tel.: +44 114 2226604; fax: +44 114 2766515.

E-mail address: m.heron@sheffield.ac.uk (M. Heron).

drawings or photographs of a typical human body presented in a variety of postures. Following habituation, infants were presented with a series of “scrambled” human body shapes in the test. Scrambled bodies were constructed by moving the limbs to non-canonical locations (e.g. arms and legs interchanged, arms protruding from head) while maintaining symmetry of the overall pattern. An analysis of infants’ looking to the scrambled body pictures revealed dishabituation to the scrambled human body shapes in infants older than 15 months. In contrast, 12-month-old infants were not sensitive to the line drawings or photographs of the scrambled body shapes.

Further studies by [Slaughter and Heron \(2004\)](#) investigated infants’ ability to categorize typical and scrambled dolls using the object examination task. The procedure was analogous to the visual habituation procedure, with familiarization to a series of typical dolls followed by presentation of a single scrambled doll on the test trial. Infants’ manual exploration of the stimuli, instead of visual attention alone, was measured. By 24 months infants were sensitive to all scrambled body shapes. Fifteen- and 18-month-old infants were only sensitive to one of the three scrambled body shapes tested (in which the dolls arms were attached to the head). Again, 12-month olds showed no sensitivity to scrambled human body shapes.

Thus robust discrimination of typical and scrambled human body shapes was observed at 15–18 months in the visual habituation paradigm, but not until 24 months in the object examination task ([Slaughter & Heron, 2004](#)). This age discrepancy is consistent with previous research that has revealed earlier categorical distinctions in tasks that require visual versus manual responding ([Mareschal & Quinn, 2001](#); [Younger & Furrer, 2003](#)).

To date, there has been no investigation of infants’ spontaneous categorization of typical versus scrambled human body shapes, via an unstructured behavioral task such as sequential touching. In this procedure, infants are presented with an array of objects, usually comprising of two different categories, with four exemplars in each category. Infants are allowed to spontaneously manipulate the objects. The order in which each infant touches the objects and the frequency of touches to different objects from each category are recorded. If infants systematically touch items from one category more often than expected by chance, categorization is inferred. The cognitive demands imposed by the sequential touching task are thought to be greater than those imposed by structured behavioral tasks such as object examination. In the object examination task the categories are made explicit by providing infants with several exemplars of a single experimenter-defined category, followed by an exemplar from the other category. In the sequential touching task multiple objects from two categories are presented simultaneously, thus the task provides less structure in terms of the relevant category distinction. The sequential touching task requires infants to make an explicit judgment that two or more objects share something in common ([Mareschal & Quinn, 2001](#); [Oakes et al., 1996](#)).

[Johnston, Madole, Bittinger, and Smith \(2001\)](#) used a sequential touching task to explore 18-, 22- and 30-month-old infants’ ability to categorize human bodies based on gender. In their study, four male and four female dolls representing a variety of ethnicities and different ages were presented to infants. Only a small minority of the infants categorized the genders at 22–30 months of age (overall, this finding was not significant). However, using the same stimuli in an object examination task, infants distinguished the categories of male and female at 14 months of age. This discrepancy again suggests that infants’ spontaneous categorization, reflected in sequential touching, emerges a good deal later than in a structured behavioral task like object examination. These results indicate that spontaneous categorization of human bodies based on gender attributes may not emerge until some time after age 2.

The current study had two aims. The first was to extend recent research on infants’ emerging human body knowledge. The second, related aim, was to investigate the question of whether knowledge about the human body shape is privileged relative to other familiar object categories. All previous research on infants’ responses to human bodies has compared responses to bodies versus faces, or bodies versus abstract figures; to date no study has compared infants’ responses to bodies versus other complex familiar objects. Therefore in the current study, the following question was posed: Does knowledge of human bodies develop before or after knowledge of other objects, such as cars? Cars were chosen as the objects for comparison, since they are similar to humans in a number of ways. Both are ubiquitous, familiar objects, which have specific functional parts in a canonical configuration, yet all exemplars are individuals. However, knowledge about human bodies may be unique, at least in part because we experience them from both the inside and outside. Our human body representations may differ from our representations of other objects because we have constant proprioceptive and kinesthetic inputs that arise from moving our own bodies, as well as visual inputs that arise from viewing other people’s bodies. Indeed, some authors suggest that mapping from viewed bodily movements to one’s own bodily movements is an ability that is present at birth ([Gallagher, Butterworth, Lew, & Cole, 1998](#); [Meltzoff, 2007](#); [Meltzoff & Moore, 1995](#)). This “supramodal” body representation may not directly specify the canonical structure of the human body, but it should facilitate infants’ learning about the appearance of the human body, relative to learning

about other objects for which only visual information is available. Thus there may be a privileged representation of the human body in infancy, and infants may not need to learn about the structure of human bodies in the same way that they learn about the structure of other objects.

Results from recent neuroimaging studies with adults support the hypothesis that human bodies are represented differently from other objects. This work builds on the well-replicated finding that the adult brain is selectively responsive to human faces, exhibiting activation in dedicated brain regions, as well as characteristic event-related potential (ERP) patterns, in response to facial stimuli (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Kanwisher, McDermott, & Chun, 1997). Face-specific responses are often contrasted with responses to cars, for which there are neither specific areas of activation nor characteristic ERPs. Researchers have recently discovered that there is a dedicated area in the adult brain that selectively responds to human bodies and recognizable body parts but not to many types of other objects, including faces and cars (Downing, Jiang, Shuman, & Kanwisher, 2001). This area, called the extrastriate body area (EBA) is located in the lateral occipitotemporal cortex. Its identification suggests that bodies, like faces, are represented differently from other objects, via dedicated neural architecture, at least in adults.

Neuroclinical evidence also indicates dissociation in the way adults represent faces and bodies versus other objects. For example, patient MT cannot recognize familiar faces, however he can discriminate between different brands and models of cars (Henke, Schweinberger, Grigo, Klos, & Sommer, 1998). In a similar vein, some patients with brain damage have difficulty in locating parts on the human body, but do not have this difficulty with other objects (Denes, Cappelletti, Zilli, Porta, & Gallana, 2000; Ogden, 1985). There is also evidence to suggest that language-based knowledge for human body parts may be distinct from lexical-semantic knowledge for other objects (Shelton, Fouch, & Caramazza, 1998). These disorders further suggest that body representations are distinct from representations of other common objects.

There is good reason to assume that infants' learning about human bodies may occur earlier and follow a distinct developmental trajectory, from their learning about other objects like cars. If this is the case, we would expect infants to demonstrate knowledge about the typical shape of the human body before they demonstrate knowledge about the typical shape of cars, in which case discrimination of typical and scrambled dolls should occur before discrimination of typical and scrambled cars.

We tested this hypothesis using sequential touching tasks, in order to examine infants' spontaneous responses to human bodies, represented by dolls, and to cars, represented by toy automobiles. Children aged 18, 24 and 30 months old were presented with four typical and four scrambled exemplars in each category. Infants' touching behaviors were recorded. Following standard criteria, infants were credited with discriminating the typical and scrambled exemplars if they sequentially touched exemplars from one of those categories more often than expected by chance. We also assessed language-based knowledge about human bodies and cars in this task, by recording infants' comments about the stimuli (i.e. whether objects were typical or scrambled). This included both spontaneous comments and those in response to questioning. No previous studies have analyzed verbal responding to typical versus scrambled human bodies. Body part naming studies suggest that infants acquire up to a dozen names for individual body parts between 12 and 24 months of age (Witt, Cermak, & Coster, 1990). However, this skill may not reflect infants' knowledge about the whole human body shape. Identifying typical and scrambled bodies/cars is presumably a more difficult task than body part identification, since children must consider several exemplars and several body parts simultaneously, rather than focusing on just one specified body part at a time, on a single exemplar. Thus it was hypothesized that it might not be until 30 months of age that the majority of infants would be able to verbally identify which dolls and cars were typical and scrambled.

We also explored gender differences in categorization of the dolls and cars, since gender-stereotyped toy preferences are evident in the second year of life (Campbell, Shirley, Heywood, & Crook, 2000; Fagot, Leinbach, & Hagan, 1986; O'Brien & Huston, 1985). Gender effects have also been observed in body part identification tasks (MacWhinney, Cermak, & Fisher, 1987) although similar studies found no gender differences in performance (Johnston et al., 2001; Witt et al., 1990). There is also some suggestion that gender interacts with performance in the sequential touching procedure (e.g. Levy, 1999). Thus there is no clear basis for making predictions about the influence of gender on performance. It may be that gender has no impact, and all children categorize the typical and scrambled dolls before the cars (for the aforementioned reasons) or it may be that gender stereotyping of the stimuli influences performance. In this case we would expect girls to discriminate the typical and scrambled dolls before the cars, and boys to do the reverse.

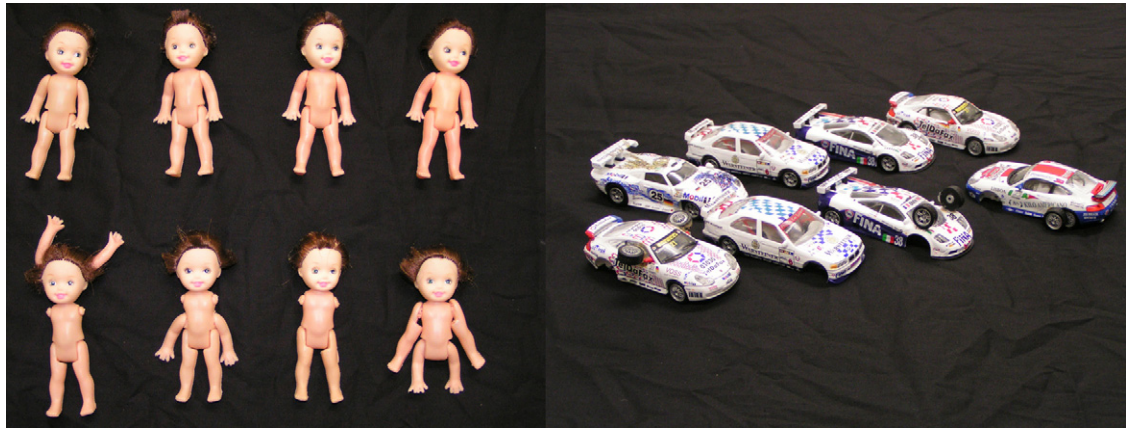


Fig. 1. Typical and scrambled dolls and cars.

1. Method

1.1. Participants

Infants' names were taken from birth announcements of a local newspaper, or from an existing subject pool. Parents were contacted via mail and telephone and anyone who volunteered to participate did so. The sample was mainly Caucasian (98.5%), living in suburbs around the Brisbane metropolitan area. Statistical analyses were based on a total of 24, 18-month olds (M age = 18 months and 4 days: range 17 months 16 days to 18 months 14 days; 11 boys, 13 girls); 26, 24-month olds (M age = 24 months and 3 days: range 23 months 16 days to 24 months 14 days; 11 boys, 15 girls); 26, 30-month olds (M age = 30 months and 16 days: range 30 months 0 day to 30 months 30 days; 12 boys, 14 girls). An additional two 18-month olds, four 24-month olds and three 30-month olds were tested but excluded from the final sample due to refusal to cooperate (throwing objects on the floor continuously).

1.2. Materials

The stimuli consisted of eight dolls, eight miniature toy cars (see Fig. 1), and eight training items. The training items were balls (diameter = 4 cm) and blocks (size = 4 cm). The human figures were made of hard plastic (excluding the dolls' hair) and were presented naked (height = 10 cm). Four of the dolls were typically shaped and four were scrambled. The scrambled body doll shapes were as follows: (a) arms attached at ears and raised upwards, (b) arms hanging by sides but attached at hips, (c) arms removed from body and (d) legs attached at shoulders and arms attached at hips. Before manipulation of body shape all dolls were identical. The cars were white with colorful patterns and black rubber wheels (length = 10.5 cm). Four were typical in shape and four were scrambled, in a manner analogous to the dolls: (a) wheels removed from front of car and placed on bonnet directly above the headlights, (b) wheels removed from front of car and attached directly in front of back wheels on the side of the car, (c) front wheels removed and (d) front wheels removed from front of car and placed on side windows of car in an outwards fashion. Both the typical and scrambled cars' wheels moved, thus cars could be rolled across the table.

1.3. Procedure

The infant was seated in an infant seat at a table, across from the experimenter. The mother sat on the left of the infant, and a video camera was positioned to the right for recording infants' responses. Each infant participated in three conditions: training, dolls and cars. First, a training task was administered to familiarize infants with the task. Infants were presented with four balls and four blocks arranged in a random fashion on a tray, as well as two baskets. The tray was covered with a thin black rubber mat to prevent objects from sliding. The experimenter encouraged the infant to play with the objects by saying "Look at these", and "What can you do with these". Infants were allowed to handle and manipulate the objects freely for 2 min, with no feedback about their sorting behavior. Infants could remove objects

from the tray and place them on the table. After 2 min of free play, infants were encouraged to sort the objects into two baskets (if no sorting using the baskets had already occurred). Children were also questioned regarding category membership (e.g. “What is this?” while pointing at an object). If children had difficulty completing the sorting task, the experimenter demonstrated how to sort the objects, e.g. “All of these go in this basket”, while placing all the balls in one basket. This demonstrated that the aim was to sort the objects into two different categories.

Next, infants were presented with either typical and scrambled cars, or typical and scrambled dolls (ordering was counterbalanced across infants). The procedure was identical to that described above, with two differences. First, the experimenter never demonstrated how to categorize the objects (manually or verbally). Secondly, the manner in which children were questioned about category membership differed from the training task (see Section 1.4.2 for more detail). The entire session lasted approximately 10 min.

1.4. Coding and scoring

1.4.1. Touching behavior

Coding and scoring were the same as in previous studies that used the sequential touching technique (Mandler, Bauer, & McDonough, 1991; Rakison & Butterworth, 1998). Coding focused on the infants’ sequential touching of objects. Touches were counted if the infant touched the object by hand or with another object. Accidental touches to objects were not recorded (i.e. if no attention was paid to the object). Sequential touches to the same object were counted as one touch unless they were separated by a touch to another object. The order in which the objects were touched was coded.

Infants’ sequential touching behaviors were analyzed in several different ways. Procedures for analyses were taken from those developed by Mandler, Fivush, and Reznick (1987). The first measure determined whether sequential touching differed significantly from chance performance for each age group of infants. The mean run length (MRL) of successive touches to the items of each category was calculated for each child, on each task. The MRL was calculated by dividing the total number of touches in a given sequence by the number of runs of successive touches exhibited in that sequence of touches. The MRL was compared with the run length expected by chance (1.75) if items from two sets of four objects were selected randomly. The MRL indicates if touching behavior is systematic rather than random for each category, but it does not provide detailed information about the type of touching that occurred. The MRL measure does not indicate if infants attend to objects from one category or both categories, or whether they touched only a subset of the objects or all the objects in a category. Therefore another measure of run length was calculated.

Adopting the criterion of previous research (e.g. Starkey, 1981), touches of at least three unique items in a row from a category were assessed to see if the child demonstrated categorization of that set of objects beyond what would be expected due to chance. A Monte Carlo program (TouchStat) was used to determine the likelihood of one or more categorization runs occurring by chance, taking into consideration the total number of objects touched, the number of categories and how many objects are in each category, the number of touches made within a run and how many unique items were touched within a run. The program computed how often a particular categorization run (or runs) of three or four items would occur in 10 000 random draws (cf. Dixon, Woodard, & Merry, 1998). For example, a run of 5 touches to 4 different dolls, in the context of 10 total touches is associated with a probability of $p = .03$. As in previous studies $p < .10$ was the cut-off point for significance (e.g. Mandler et al., 1987; Rakison & Butterworth, 1998). If a child’s probability was below the .10 cut-off, the run of touches was deemed to exceed what would be expected by chance, and the child was classified as a categorizer. In accordance with previous categorizing studies, infants who systematically touched objects from one category were classified as single categorizers, and infants who systematically touched objects from both categories were classified as dual categorizers.

1.4.2. Verbal behavior

Throughout the course of the procedure many children made spontaneous comments regarding category membership. Upon presentation of the dolls, one infant picked up a scrambled doll and exclaimed “Oh no! Baby is broken.” Another child commented “No wheels – it’s broken!” when presented with a scrambled car. This was typical of the manner in which spontaneous comments were made. If a child spontaneously labeled all eight objects in the set, no questions were asked by the experimenter. If the child did not label all objects, after 2 min of free play the child was questioned regarding category membership of the objects. This started with general questions such as “What can you tell me about these babies/cars?” and became more specific if the child did not respond, e.g. “Is this baby ok?”, “Is this car

broken?” Variations of these words were used by the experimenter as necessary, to use terms that the child appeared to understand.

Verbal responses which were counted as reflecting knowledge about the typical dolls/cars were as follows: “ok”, “good”, “fixed” or complete sentences indicating that body parts were in the correct location (e.g. “This baby is alright”). Verbal responses counted as correct for the scrambled cars/dolls were as follows: “broken”, “bad”, “not ok”, “wrong” or sentences explaining what was wrong with the doll/car in question (e.g. “The arms are missing”). Verbal knowledge was also credited if children responded with “yes” and “no” correctly in response to questions about whether the doll/car was broken or ok. Scores were adjusted to avoid giving credit for chance responding (see below). If the child exclaimed “Oh no!” in responses to a scrambled doll/car, this was not counted as language-based knowledge if it was the only utterance made by the child. However in this instance the child was questioned about the object to elicit further explanation. General utterances about the dolls/cars (e.g. “baby”) which did not refer to the typical/scrambled nature of the objects were not coded. The vast majority of verbal comments recorded were spontaneous (81%), rather than in response to questioning (19%).

Children scored one point for every object that they correctly identified as belonging to a particular category, thus the maximum score in both conditions was 8 (each condition included eight objects). The number of objects incorrectly identified was also totaled. Objects that were not labeled, or labeled in a manner irrelevant to category membership (e.g. “baby”) scored 0. Children’s verbal score was represented by the total number of objects correctly identified minus the number of objects incorrectly identified. This meant that if a child labeled everything in the same manner (e.g. “broken”) then they would score 4 correct, and 4 incorrect, giving them an adjusted score of 0 correct. Similarly, if a child was labeling objects randomly it would be expected that they would get approximately half right and half wrong, scoring close to 0. However children who only responded to one category (e.g. labeled all four scrambled objects as “broken”), while not referring to the other category at all would still score 4 out of 8 correct. So in this case chance responding would be reflected in a score of 0, while 4 out of 8 correct would suggest performance was not at chance level. As incorrect responding was not common (only five children gave an incorrect label throughout the entire procedure) adjustments to scores were minor.

1.5. Reliability

For both touching and verbal behavior, a second judge independently coded 25% of the data. For touching behavior, inter-rater reliability was obtained by calculating the percent agreement between the different objects scored as touched, and the order in which items were touched, by the judges. Percent agreement for objects touched by the infants was 95%. For verbal behavior, inter-rater reliability was obtained by calculating the percent agreement between the reported verbal labels given to the objects for each child. Percent agreement was 99.5%. Statistical analyses were based on the coding of the first observer.

2. Results

2.1. Run length analysis

The first analysis compared the mean run lengths for the two tasks to the run lengths expected by chance (1.75). One-tailed *t*-tests¹ (test value = 1.75) revealed that the 24- and 30-month-old boys categorized the typical and scrambled cars via systematic touching (see Table 1). However, boys did not categorize the typical and scrambled dolls at either age (i.e. they produced run lengths at chance level). Thirty-month-old girls categorized the typical and scrambled dolls and cars, however the 24-month-old girls did not. The 18-month-olds only categorized the balls and blocks. Analyses of MRL for the training items was not conducted for the older infants since responses to these items was not of particular interest, beyond ensuring that infants could in fact respond in such a task.

¹ A one-tailed *t*-test involves rejecting the null hypothesis for only the highest MRL scores (not for both high- and low-MRL scores). This is appropriate because the specific question being addressed here is: Do children have significantly *higher* MRLs than expected by chance? (one-tailed test). Not, do children have significantly *different* MRLs from chance? (two-tailed *t*-test). Low scores indicating MRLs significantly below chance are not of importance in this analysis.

Table 1

Mean run length, standard deviation and associated *t*, d.f. and *p* values for each age and condition, split by gender

Age	Gender	Condition	MRL	S.D.	<i>t</i>	d.f.	<i>p</i>
30-Month olds	Boys	Dolls	1.84	.54	.58	11	.290
		Cars	1.98	.48	1.68	11	.061*
	Girls	Dolls	2.36	.89	2.54	13	.012*
		Cars	1.92	.48	1.33	13	.100*
24-Month olds	Boys	Dolls	1.66	.83	.34	10	.370
		Cars	2.30	.89	2.07	10	.033*
	Girls	Dolls	1.72	.52	.19	14	.426
		Cars	1.98	.97	.93	14	.185
18-Month olds	Boys	Dolls	1.73	.41	.17	10	.433
		Cars	2.17	1.10	1.25	10	.119
	Girls	Dolls	1.65	.55	.65	12	.265
		Cars	1.63	.391	1.14	12	.139
	Both	Ball/block	3.03	1.66	5.76	23	.001*

* Significant at $p < .10$.

The run lengths were investigated further with a three-way mixed-design ANOVA, with Age (18, 24 and 30 months), and Gender (male, female) as between-subjects variables, and Condition (dolls, cars) as a within-subjects variable. A significant two-way interaction between Gender and Condition was revealed, $F(1,70) = 4.32$, $p = .041$, $\eta = .06$. To follow-up the significant interaction the simple effects of Condition at each level of gender were calculated. Paired *t*-tests revealed that for the boys, MRLs for the typical/scrambled car task were significantly longer than for the typical/scrambled doll task, $t(33) = 2.21$, $p = .034$ ($M_s = 2.15$ and 1.75 , $S.D.s = .84$ and $.60$, respectively). For the girls no difference in MRLs for the dolls and the cars was observed, $t(41) = .41$, $p = .68$ ($M_s = 1.91$ and 1.85 , $S.D.s = .73$ and $.68$, respectively). Thus boys demonstrate superior categorization of the typical and scrambled cars than the typical and scrambled dolls, while girls perform similarly on the two tasks.

2.2. Monte Carlo analysis

A Monte Carlo program was used to compare the number of infants who made categorizing runs of three or four touches with that expected at chance level. Table 2 shows the percentage of infants classified as single or dual categorizers and the mean run lengths of any categorizing runs made. Table 2 shows that children's categorization of typical and scrambled dolls and cars steadily increased between 18 and 30 months of age. At each age more categorization occurred

Table 2

Percentage of categorizers and mean categorizing run lengths (standard deviations in parentheses)

Categorization classification	Age group					
	18-Month old		24-Month old		30-Month old	
	%	MRL	%	MRL	%	MRL
Typical dolls vs. scrambled dolls						
Single	4.2	3.00 ^a	11.5	2.90 (.52)	15.4	1.86 (.19)
Dual	0	0 ^a	7.7	2.77 (.80)	30.8	2.99 (.76)
Total	4.2		19.2		46.2	
Typical cars vs. scrambled cars						
Single	12.5	3.61 (1.34)	11.5	2.81 (.61)	15.4	1.85 (.26)
Dual	4.2	1.82*	23.1	2.86 (1.09)	50.0	2.26 (.37)
Total	16.7		34.6		65.4	

^a Insufficient sample size to calculate standard deviation.

on the car task than the doll task. For both the 24- and 30-month olds there were considerably more dual categorizers than single categorizers. Overall, this suggests that infants were not responding to a few salient objects to make the categorical discrimination. Instead, they were considering both categories. The tendency toward dual categorization increased with age. Again, 18-month olds demonstrated an ability to categorize the balls and blocks. Overall, 70% of infants were classed as dual categorizers ($M = 3.73$, $S.D. = 1.48$).

In general the MRLs were quite low. This may be because the older children tended to consider each individual item and assign category membership verbally, rather than considering all the items and touching the items from one category and then touching items from the other category. Overall the findings of the Monte Carlo analysis are consistent with results obtained from the run length analysis.

2.3. *Analyses of object salience*

It was possible that single or dual categorizing could have occurred because of the greater salience of one or more objects or of a category as a whole. Therefore several analyses of salience were performed to investigate this possibility. In line with Mandler et al. (1987), the most salient category was defined as (a) the object set most often categorized by single categorizers or (b) in the case of dual categorizers the object set categorized first. Chi-square tests were used to examine the number of infants who chose each category (typical or scrambled) for each set of objects (dolls and cars). No preferences for one category of objects over the other category were detected, for any age group. The second test of salience, using paired t -tests (Rakison & Butterworth, 1998), revealed no significant difference in the number of touches to the typical and scrambled objects in each condition for any of the age groups. Finally, one-way ANOVAs indicated no significant differences in the number of touches to each of the individual objects (including both cars and dolls) within the normal object set, and also within the scrambled object set, collapsed across category (cars and dolls) membership. In other words, infants did not touch any particular typical object (car or doll) significantly more than any other typical object. This was also the case for the scrambled objects. Therefore the number of touches to each item within an object set was evenly distributed. Overall, these analyses indicate that categorization was not due to a few highly salient objects or due to one particularly salient category of objects (i.e. typical versus scrambled objects).

2.4. *Verbal response analysis*

Eighteen-month-old infants' responses were not included in the following analyses since all children in this age group scored zero on the verbal response measure. A 2 (Age: 24 and 30 months) $\times$ 2 (Gender) $\times$ 2 (Condition: dolls and cars) mixed model ANOVA revealed significant main effects of Condition, $F(1,48) = 65.02$, $p = .001$, $\eta = .58$; Age, $F(1,48) = 66.23$, $p = .001$, $\eta = .59$. Significant Condition $\times$ Age, Condition $\times$ Gender and Age $\times$ Gender interactions emerged, however these effects were qualified by a significant Condition $\times$ Gender $\times$ Age interaction, $F(1,48) = 8.58$, $p = .005$, $\eta = .15$ (see Fig. 2).

Follow-up paired t -tests revealed that the 24-month-old boys had higher verbal categorization scores for the cars than the dolls, $t(11) = 3.39$, $p = .007$, as did the 30-month-old boys, $t(11) = 10.54$, $p < .001$. The 24-month-old girls showed no differences in verbal scores for the cars or dolls, nor did the 30-month-old girls (see Fig. 2). Also to be noted from Fig. 2, the earliest evidence of correct labeling occurred at 24 months in response to the typical and scrambled cars, but only for boys.

2.5. *Summary of infants' touching behavior and verbal responses*

With sequential touching (MRL) as the dependent variable, categorization of typical and scrambled cars was observed at 24 months, but only for boys. Categorization of typical and scrambled bodies was observed later, at 30 months, but only for girls. Furthermore, boys' MRLs were longer for cars than dolls, while girls performed equivalently on the doll and car tasks. Thus gender influences performance. In line with this, the Monte Carlo analysis showed superior categorization of cars compared with dolls at 24 and 30 months of ages. When verbal categorization (labeling) was examined, again, boys' categorization of cars was superior to that of dolls, whereas girls' performance was equivalent. Language-based knowledge of typical and scrambled bodies was not reliable until 30 months, and even at this age it was only reliable for girls. In contrast, some language-based knowledge of typical and scrambled cars was demonstrated at 24 months, but only by boys. Thus overall, both touching behavior and verbal responses revealed earlier knowledge

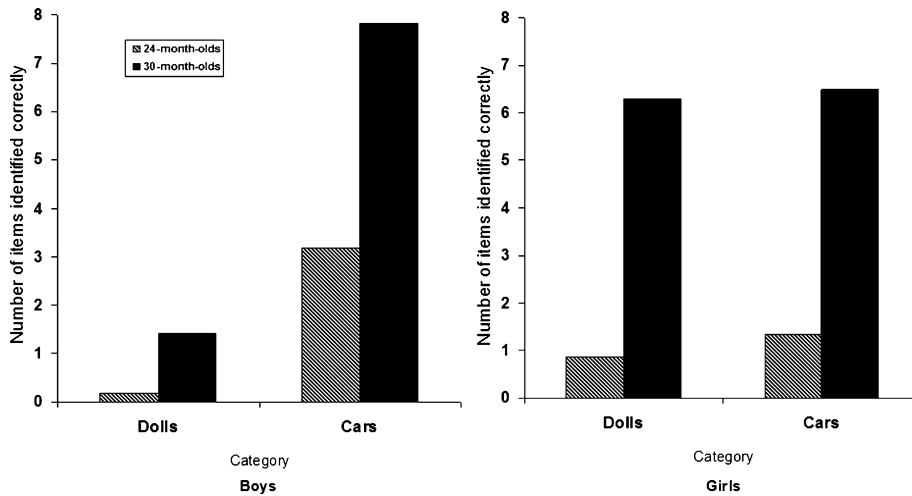


Fig. 2. Number of typical and scrambled dolls and cars identified correctly verbally by 24- and 30-month-old boys and girls.

of the overall configuration of cars than dolls, however results must be interpreted with caution due to the gender differences in performance.

3. Discussion

This study investigated infants' ability to explicitly categorize typical and scrambled dolls and cars using a sequential touching task, and also assessed language-based human body knowledge. Thirty-month-old girls successfully categorized the typical and scrambled dolls, and the typical and scrambled cars via sequential touching. Same-aged boys only categorized the typical and scrambled cars. The 24-month-old boys categorized the typical and scrambled cars, but did not distinguish the typical and scrambled dolls, and the 24-month-old girls did not categorize dolls or cars. These findings are consistent with previous research. Children do not differentiate male versus female dolls until around 30 months of age (Johnston et al., 2001). Typical versus scrambled bodies and male versus female bodies are both relatively low-contrast comparisons, since perceptual variability between the categories is low. Thus it is perhaps not surprising that infants do not spontaneously categorize typical and scrambled bodies until 30 months of age.

Knowledge of typical and scrambled body shapes was demonstrated later in the sequential touching task (30 months) than has been previously demonstrated in the object examination and visual tasks (beginning at 15 months, Slaughter & Heron, 2004), even though the sequential touching task used in the current study was highly simplified by providing typical exemplars in identical configurations. In theory, this should have facilitated discrimination of the typical and scrambled dolls/cars. Nonetheless, later responding in the sequential touching task was not unexpected. The sequential touching task is far less structured than the visual/object examination tasks, so children must discover the relevant categorical distinction themselves by considering several exemplars from two categories simultaneously and touching objects from only one category (e.g. typical bodies) before touching objects from the other category (e.g. scrambled bodies). Thus as the task becomes less structured, and the response more challenging (i.e. explicit active categorization), infants find it harder to access and demonstrate their categorical knowledge. The overall pattern of findings is consistent with past research (e.g. Johnston et al., 2001; Oakes et al., 1996) and supports the conclusion that categorization in infancy is largely task dependent.

Another example of task parameters influencing performance is evident when comparing infants' performance on Witt et al.'s (1990) body part identification task with performance on the current task. Infants are capable of pointing to specific body parts at 24 months of age, however apparently this is not sufficient knowledge for discriminating typical and scrambled bodies in a sequential touching task. This may be because pointing to body parts imposes fewer information processing demands, since infants must only focus on one specified body part at a time on a single exemplar, rather than considering several exemplars and several body parts simultaneously as in the sequential touching task. Thus when task demands are increased, infants may not be able to access or express all they know about the human body shape.

Infants' verbal responding was consistent with their touching behavior. Labeling of typical and scrambled cars began before labeling of dolls, at around 24 months of age for the boys. By 30 months both boys and girls reliably labeled the cars as typical versus scrambled (using words like "broken" and "ok"). At 30 months girls could label the dolls as typical and scrambled, however boys did not.

Across both measures (touching and verbal) boys' ability to categorize the typical and scrambled cars preceded the ability to categorize typical and scrambled dolls. In contrast, girls performed equivalently on the two tasks. Overall, knowledge of cars was demonstrated before knowledge of dolls, due to boys' early responding to cars. Girls did not exhibit gender-stereotyping behaviors towards the stimuli and demonstrated knowledge of cars and dolls at the same point in development. For both genders there was no evidence of earlier responding to dolls than cars. Thus it appears that violations of the human body shape are no more salient than violations of other meaningful objects such as cars. This suggests that early in development recognition of the structure of the human body does not have privileged status, and that infants have to learn about the structure of the human body just as they have to learn about non-human artifacts such as cars. This may mean that the apparent privileged status of body representations, suggested by the existence of body-specific brain sensitivity, is not given at birth but develops over the first several years of life. Confirmation of this hypothesis will ultimately require neuroimaging data from young infants.

It is highly unlikely that 30-month-old boys have a genuine deficit in knowledge about the human body. It is more likely that this knowledge was not demonstrated because boys were not interested in touching or talking about the dolls. A large body of research has documented boys' preferences for cars, starting as early as 9 months of age (Blakemore, LaRue, & Olejnik, 1979; O'Brien & Huston, 1985; Serbin, Poulin-Dubois, Colburne, Sen, & Eichstedt, 2001). Boys may have been more interested in the cars due to their color, the movement of the wheels, because they are perceived as masculine, or a combination of these and other factors. It stands to reason that if boys were more interested in the cars, they would be more attentive to this category of objects, and spend more time processing the characteristics of the cars. This would increase the chance of boys noticing the scrambled cars (relative to dolls) and facilitate categorization of the typical and scrambled cars (both manually and verbally). Thus interest level appears to interact with boys' ability when categorizing dolls and cars as typical and scrambled.

Another factor which may influence the pattern of results is the use of miniature models to represent real life referents. Do children respond similarly to miniature replicas and their real-world equivalents? This relates to the issue of task dependency, in that the nature of the stimuli presented to infants can influence performance, and also relates to representational understanding. By 2 years of age children understand that pictures can stand for real world entities (Preissler & Carey, 2004; Suddendorf, 2003). However scale models, like those we used, are more compelling than pictures as objects in their own right (because they are also toys, see DeLoache, 2000). So while children may have understood the doll–real person correspondence, they are also familiar with using dolls as toys and so they may have been primarily perceived as toys rather than representations for real world entities. This might explain the boys' reticence to engage with the human body stimuli. Following from this argument, if children were presented with typical and scrambled real cars and real humans, gender effects might be annulled, and the finding that boys only respond to cars, and that knowledge of cars precedes knowledge of humans may not emerge. Although real cars are stereotyped as masculine objects to a certain extent, humans are certainly not stereotyped as feminine objects in the way that dolls are. Thus one must be cautious in drawing strong conclusions regarding infants' knowledge of the real world domains of humans and cars, based on their responses to miniature replicas. However, given that it would be next to impossible to assess infants' spontaneous categorization of real humans and real cars, the current experiment provides the best means of testing infants' categorization abilities across these domains.

Future research should examine language-based body knowledge in older children to assess further advancements in human body knowledge throughout the preschool years. Additionally, future studies should employ procedures which can incorporate real referents rather than representations of humans and vehicles, to avoid gender-driven toy preferences influencing the ability to categorize dolls and cars.

In conclusion, this study revealed that knowledge of the human body shape is partially task dependent. The sequential touching task, which is low in structure, elicited responding later in development (30 months) than highly structured tasks such as visual habituation and object examination (15 months; see Slaughter & Heron, 2004). Language-based knowledge about the overall structure of the human body shape was not evident until 30 months of age, and was only reliable for girls. Thus it is advisable to employ a variety of techniques in order to gain a thorough understanding of children's knowledge in a given domain (Woolley, 2006). Finally, human body knowledge does not appear to have

privileged representation in infancy. Instead, it appears that infants must learn about the configuration of the human body shape, just as they have to learn about other objects in their environment.

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